In the matter of:

Amendment of Parts 73 and 74 of the	)	
Commission's Rules to Establish Rules for Digital	)	MB Docket No. 03-185
Low Power Television, Television Translator, and	)	
Television Booster Stations and to Amend Rules . .	)	
for Digital Class A Television Stations	)	

NOTICE OF PROPOSED RULEMAKING

Adopted: August 6, 2003 **Released: August 29, 2003**

CORRECTED Reply Comments of:

NOTE: These comments contain corrections to the previously submitted reply comments dated 12/23/03.

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Gary Sgrignoli hereby submits these comments in response to the Commission's Notice of Proposed Rulemaking ("Notice"), document FCC-03-198, MB Docket No. 03-185, adopted on August 6, 2003, released on August 29, 2003, and published at 68 FR 55566 on September 26, 2003. This Notice concerns the authorization and deployment of digital television translators, boosters, and low power television (LPTV) stations. Where possible, the Commission's paragraph numbers used in the Notice will be referenced to facilitate the reading of the following text.

1.0 GENERAL COMMENTS:

I applaud the Federal Communications Commission (FCC) for proposing rules for *digital* low power television (LPTV), translators, and booster stations. With the full-service station transition well underway, bringing digital television (DTV) to the *rural* areas is very timely. I agree that "translators and LPTV stations will play a significant role in furthering the transition to digital television" and that "many people living in rural areas are essentially dependent on translators to bring them their only *free*, over-the-air television service (signals and programming)". Both commercial and non-commercial stations are enjoyed by millions of rural viewers because of the translator systems spread throughout the areas of this country with more rugged terrain.

I agree that "spectrum availability presents a great challenge to the digital conversion of TV translators" and that "the pace at which these stations begin to operate digitally may depend on the ability of station licensees to secure additional channels". Careful selection of interference criterion and new analysis methodology should allow both a quick and safe transition to digital television service in the rural areas by efficiently using and re-using the scarce spectrum that is currently available. "Thinking outside the box" will be a necessity in both policy and technical requirements along with an increased cooperative spirit among broadcasters and translator operators.

While there are many technical and non-technical issues regarding the adoption of new FCC rules, I will primarily address the *technical* issues regarding RF interference protection rules and the methodology that can be employed to provide as much spectrum as possible in *rural* areas of this country. Of course, this is to be accomplished without causing unacceptable interference into *existing* urban and rural facilities.

While the following comments may apply to LPTV and booster stations as well, the primary focus will be on digital *translators*. I believe that translators are just an *extension* of the primary full-service station since they currently pass through analog signals unaltered (other than frequency and amplitude), provide "no original programming" (except for a maximum of 30-seconds of public service announcements once per hour or emergency warnings of imminent danger), and "rebroadcast the programs and signals of DTV stations". Their main purpose today is to "provide service (outside *or* inside the Grade B contour of a full-service station) to areas where "direct reception of full-service broadcast stations is unsatisfactory because of distance or intervening terrain obstructions", provided they have received written consent from the TV station. Under current law, translators can receive their input signal from the full-service stations directly, other translators, or from a microwave feed. Most of the translators are located in the rural areas of the western United States, although translators can be found throughout the entire country. Spectrum policy and spectrum allocation will be more difficult to implement in the more densely populated urban areas than the less densely populated rural areas. However, this should not impede the rural areas from immediately receiving the benefits of DTV, thus extending the "footprint" of the full-service TV stations. In this, the rules must be flexible and forward thinking so that spectrum re-packing at the end of the transition period is facilitated.

Therefore, new *digital* translator rules should exist with as much flexibility as possible, which is important to such a class of secondary-service stations that are "not restricted to operating on a channel specified in a table of allotments" like full-service stations. Many of the same *types* of rules in place for full-service DTV stations can stay in place for *digital* translators, while new rules can specifically deal with the spectrum efficiency required to provide translator channels during and after the transition. However, it should be noted that unreasonable financial burdens should *not* be placed on translator operators who try to transition from analog to digital.

2.0 BACKGROUND

Black and white analog television, commonly referred to by its historical name of National Systems Television Committee (NTSC), was adopted as a standard in the U.S. since 1941 (color adopted in December 1953). In 1987, proceedings began in the U.S. when television broadcasters asked the Federal Communications Commission (FCC) to develop high definition television (HDTV) standards. This development turned into what we know of today as digital television (DTV). When the FCC adopted the Advanced Television Systems Committee (ATSC) digital television system (**Ref 1**) as the standard of the United States on December 24, 1996, the transition from analog to digital television officially began. Rules for *full-service* digital television stations were developed and published (**Ref 2**). Likewise, the FCC's Office of Engineering and Technology (OET) published a set of guidelines on "Longley-Rice Methodology for Evaluating TV Coverage and Interference" (**Ref 3**) to aid broadcasters. Great interest has been shown in recent years regarding the conversion from analog to digital television in the rural areas. Translators are often the primary means of bringing *free*, over-the-air television to rural viewers. However, television translators are secondary services, and must yield to full-service stations and Class A stations. This means that they may be displaced in frequency at any time (with an appropriate amount of warning time). So it is advantageous to develop methods that can best utilize the scarce spectrum presently available in order to bring more television signals to the rural areas, especially in this digital age when DTV is emerging. Of course, this cannot happen until the FCC publishes their rules for television translators, and develops planning factors for spectrum use in the rural areas. The NPRM that came out in August of 2003 is addressing this rule-making process (**Ref 4**).

One way to improve the spectral efficiency is to follow the same or similar FCC methodology used in the full-service station deployment over the past few years. However, in doing so, careful system engineering must be applied when deploying channels in a crowded spectral region in order to avoid interference among the various analog and digital signals that may co-exist for a period of time (until analog turns off, or goes "dark"). That is why spectrum-planning factors that employ interference limits and transmitter adjacent channel splatter limits via an emission mask must be developed. There are proposed translator emission masks (**Ref 5**) under consideration by the FCC in their rule-making process, and referenced in the NPRM.

One promising method of reduced interference between DTV and either existing analog NTSC signals or other DTV signals is the use of *co-sited* transmitters, such as might be the case from a multiple-channel television translator site. That is, all the "desired" (D) and "undesired" (U) signals are co-sited, and share as much of the transmitter site infrastructure as possible such as common towers, feedlines, broadband antennas, directional coupler test points, and test equipment. The advantage of such an arrangement is that the relative DTV and NTSC signal levels observed and measured in the field from each of the desired and undesired signals will vary minimally. This leaves only differential propagation effects due to the different RF channels utilized. Therefore, desired-to-undesired (D/U) ratios can be essentially controlled by carefully adjusting the TPO of each of the analog and digital transmitters at the translator sites.

Interference ratios depend upon careful determination and development of the planning factors. This is typically accomplished through precise laboratory testing of reference receivers (both analog and digital). The FCC's Advisory Committee on Advanced Television Services (ACATS) carefully administered this testing process (including the test plan) during the Grand Alliance (GA) period. ACATS laboratory testing was performed from April 19 through July 21, 1995 at the Advanced Television Test Center (ATTC), a private, non-profit organization in Alexandria, VA that was supported by the television broadcast and consumer electronics industries. The GA HDTV receiver (8-VSB modulation system, MPEG-2 video coding, AC-3 audio coding, and MPEG transport data packet communication) was extensively tested under a variety of impairment and interference conditions. Likewise, 24 reference NTSC receivers were also tested in an optimally designed viewing room at ATTC, and represented a good statistical cross-section of the consumer television receiver market in the early 1990s. ATTC used a test plan (**Ref 6**) that was approved by the FCC's ACATS group on March 24, 1995. After this date, including during the course of the GA test period at ATTC, various interpretations of, or actions on, the test plan were taken by the designated ACATS specialist group: System Subcommittee Working Party 2, System Evaluation and Testing (SS/WP2). The summary of these initial test results is documented in **Ref 7**, and published in October of 1995. The original ATTC lab test results of the GA system and several subsequent lab tests (**Ref 8, 9, 10, 11**), also performed at ATTC, are currently the only "official" and thorough lab tests readily available to the broadcast industry. These test results, which document the effects of interference testing with DTV and NTSC and are the basis for the creation of the FCC planning factors, will be used extensively in these reply comments.

3.0 DETAILS

Par. 12: **Digital translator definition, re-broadcasts, and local message insertion**

A digital translator station can be defined as "a station that receives any 19.39 Mbps incoming DTV stream consisting of at least one *free* standard definition program (no direct charge to viewer) from a full-service (primary) station, and with only minimal exceptions (e.g. station call letters), passes through the data signal in its *entirety* (with no video or audio format or quality changes) to the surrounding area using a 6 MHz terrestrial RF signal meeting the ATSC (8-VSB) transmission standard." Of course, in order to change the call letters in the PSIP stream to identify a particular translator station, a digital regenerator unit (sometimes referred to as a transcoder) must be utilized that demodulates and error corrects the digital signal to provide an error-free MPEG-transport packet stream for station call letter insertion. The above definition keeps in line with the current definition of analog translators, which is just an extension of the primary station's signal.

***Par. 13*: 2nd DTV periodic review: 85% rule interpretation when translators convert to analog for viewers or cable headends**

The technology is now mature for the *conversion* of digital MPEG streams to analog NTSC outputs in *affordable* commercial equipment. This "converter" technology can easily be applied to translators that receive and decode a *digital* ATSC stream from a full-service DTV station before re-transmitting the *analog* version of the video and audio with conventional NTSC modulation. This method has been in practice for some time at cable headends that in the past have used low-cost *consumer* set-top boxes to do just this. Likewise, rural translator operators have performed field experiments (under the FCC's Special Temporary Authorization or STA) and have supplied service to rural viewers in the same manner. Not only is this technically feasible now, but low-cost *commercial* units (with special features such as auto power on and prohibition of on-screen text) will be available next year with only modest cost increases over the current *consumer* set-top boxes that translator and cable operators have been using in the past. Rural viewers in some areas already have experienced a significant improvement in their *analog* NTSC signal quality where this type of technology has been implemented.

***Par. 14:* Heterodyne and regenerative transmission modes**

The two types of digital transmission modes under consideration are heterodyne and regenerative. While both can work in particular situations, the digital regenerator is by far the best performing and easiest to implement. The only issue currently under discussion is equipment cost.

The heterodyne unit simply frequency translates the RF signal, using a local oscillator and mixer, to some intermediate frequency (IF) such as 44 MHz, band-pass filters the IF signal, and then upconverts the signal to the final RF channel frequency before amplification. Linear pre-correction for heterodyne units in the field is very difficult at best, and may not be feasible at all.

The deficiency of a heterodyne translator is that the incoming signal is *not* improved in quality, but rather stays almost the same (at best) or becomes degraded (at worst). The signal-to-noise ratio (SNR) will become worse at the output, degrading the in-band DTV signal quality. Any signal impairments due to propagation (such as multipath, phase noise, clock jitter, etc.) are *not* corrected and may even become worse as it passes through the heterodyne unit, which will also degrade signal quality further. And any adjacent channel interference (especially first adjacent) from an analog NTSC signal or digital ATSC signal will undoubtedly pass through (at least partially, if not fully) to the output and be re-transmitted as potential interference. Also, staying within a prescribed emission mask may be difficult to both determine and enforce in cases where there are adjacent channel input signals causing time-varying amounts of adjacent channel interference power (splatter plus interferer signals) at the output of the heterodyne unit. This may cause *adjacent* channel operation of either analog or digital channels to be unavailable in these situations. Also, there is no easy way to identify each heterodyne translator, other than the old, antiquated FSK of the carrier oscillator in a Morse code fashion.

If there is no line-of-sight propagation with the source transmitter, the incoming signal to the heterodyne may be subject to great dynamic level swings due to fading. The heterodyne unit must employ AGC circuitry to keep the IF signal at the optimum operational level, as well as keep the transmitter power output (TPO) at the proper power to stay within the FCC's allocated effective radiated power (ERP) limits. If the signal fades below the level that the AGC can handle, the heterodyne is running "wide open" and the output may transmit band-pass-filtered noise (unless special circuitry is employed to "turn off" the RF output). So in only special situations should a heterodyne be used, and even then with great care. It also should *not* be used in multi-hop situations where both in-band signal distortion can accumulate as well as out-of-band interference power.

On the other hand, digital regenerative translators employ complete DTV receivers at their front ends, whether the incoming signal is a VSB signal on a single 6 MHz terrestrial (VHF or UHF) channel or it's one of four VSB signals carried on a 25 MHz broadcast auxiliary service (BAS) microwave channel (7 or 11 GHz). For VSB reception, these front-end receiver units demodulate and decode the trellis-coded 8-VSB signals, complete with multipath equalization, NTSC co-channel rejection, and forward error correction (t=10 Reed-Solomon and 4-state Viterbi trellis decoding). These units are capable of operating in severe impairment and interference reception environments just as the consumer units do, and utilize the same chip sets and tuners. (The main difference is that the translator site has professional installation of *commercial* equipment such as antennas mounted on a tower that is more than 30' height above average terrain (HAAT), coaxial downlead cable, pre-amplifiers, splitters, and some form of measurement test equipment.) As long as the impairment and interference effects do not cause the DTV receiver to extend beyond the point of threshold of visible (TOV) errors, the output MPEG-transport stream is regenerated to the exact same data stream that was transmitted from the full-service station. It is here that any simple data stream changes can be made (such as translator call letters, if needed), and the symbol clock jitter removed. This data is then processed for re-transmission as an 8-VSB signal (complete with randomization, forward error correction, and interleaving), upconverted to the desired RF output channel with a low-phase-noise oscillator and mixer, and then filtered to meet the required FCC emission mask. *Optionally*, the digital regenerator can provide automatic linear pre-correction of the filtered output signal. Another advantage is that the RF output-signal level, in-band signal quality (SNR), and adjacent channel splatter are *independent* of the incoming signal and interferers. Since each regenerator essentially produces a pristine RF signal at its output, multi-hops of many cascaded links are very possible, and have already been demonstrated in the field (see R. Kent Parson's report to the Commission in 2002 on the Utah DTV translator field testing).

If the regenerator's incoming RF signal "disappears" for whatever reason (e.g. originating stations turns off the signal or it just "fades away" due to multipath or other propagational effects), the translator will still provide a valid VSB output signal with a constant TPO and ERP. This is a desired effect, and it will keep all the DTV receivers in the service area locked up to the VSB transmission signal and waiting for the return of the video and audio. It is also possible to place within read-only memory (ROM) a short transport data stream that can be switched in temporarily and transmitted whenever there is a loss of incoming signal (e.g. when all errors are detected). This signal could provide a generic fixed text message display on all DTV receiver screens indicating "technical difficulties" rather than the misleading phrase "No Signal".

Therefore, a digital regenerator has the ability to remove noise (either white Gaussian and impulse), multipath, co-channel and adjacent channel interference, symbol clock jitter, and carrier phase noise. The digital regenerators typically have a minimum dynamic range of at least 70 dB (-10 dBm to -80 dBm), and a fixed RF output (adjusted for optimum level into the high power amplifier, or HPA). These parameters make it much easier to install in the field and produce a high quality DTV signal (in-band and out-of-band) at the translator output. The process of installing a digital regenerator is as follows:

-Measure input signal strength to determine need for pre-amp, nothing, or attenuator pad (spectrum analyzer)
-Determine amount of margin by attenuating input signal until TOV threshold is reached (variable/switchable attenuator)
-Adjust the nominal RF input signal (amplifier gain adjust or attenuator pad selection) for the desired operating point
-Adjust regenerator RF output level into HPA for best splatter at spectrum "shoulders" (monitor with spectrum analyzer)
-Adjust HPA output level for desired TPO and ERP (spectrum analyzer or power meter)
-Perform *optional* linear pre-correction, if needed and available, for best output SNR (*optional* built-in feature of regenerator)

At this point in time, the only advantage to the heterodyne unit is its lower cost, which certainly cannot be overlooked. However, as stated above, there will be new low-cost digital regenerators on the market very soon that can provide all the benefits described above at reasonable and competitive prices.

While both types of translator modes should be allowed (at least for the *initial* conversion of existing translators), it would be best for the FCC, at the very least, to limit the use of heterodyne units to cases where there are no adjacent channels at the translator input, and to encourage the "preferred" use of digital regenerators whenever possible, especially during the frequency-congested transition era.

Par. 17 **Digital translator input sources, including BAS microwave channels**

Just as in analog television, the use of alternative signal delivery means to the *digital* translator input is vital to the efficient use of spectrum in both urban and rural areas. Creating digital "backbone" systems that spread out from urban areas across rugged terrain to the far rural regions makes the most sense technically and economically. Using all means to overcome the frequency congestion without causing new or additional interference to existing primary and secondary services is crucial for the success of the transition to digital in rural areas.

Multi-hop translators are common, even in the analog world where the NTSC signal degrades each time the signal passes through a translator. In a digital world, digital regenerators allow clean signals to be present at each translator output in the "backbone". "Mountain-top-to-mountain-top" digital multi-hops have already been tested for a few years in Utah.

The use of Broadcast Auxiliary Service (BAS) frequencies with any digital modulation (on a secondary basis), as allowed in the FCC rules established in 2002, will be critical to the success of the transition in frequency-congested areas. This is because the increased robustness and spectral efficiency of the digital signal will allow more signals to be transmitted in less spectrum. For example, rather than using one FM-modulated analog signal occupying 25 MHz, four 6-MHz 8-VSB signals can be used in the same 25 MHz bandwidth (with 0.5 MHz guard-band at each end). Field tests have already been performed with three 6-MHz VSB signals (use of CH 3, CH 4, and CH 5, which all fall within the usual 70 MHz IF band of the BAS microwave transmitter and are compatible with the tuning capabilities of *consumer* DTV receivers). Four VSB signals have been tested in the lab, and can easily work in the field as well. This 4:1 spectral efficiency advantage is crucial during the transition to digital and even beyond when only core spectrum channels (CH 2 – 51) will be available.

Par. 37 **D/U signal strength ratios**

I agree with basing FCC interference standards for accepting *digital* LPTV and TV translator station application proposals on desired-to-undesired (D/U) field strength protection ratios for analysis of predicted interference to and from other digital LPTV and translator stations as well as full-service stations. The D/U ratios are the indicators in the field of the desired and undesired signal strengths that are applied to analog and digital television receiver inputs. The old method of using transmitter power output (TPO) or the more recent method of using effective radiated power (ERP) does not take into account *proximity* of the receiver under evaluation to the desired or undesired transmitter sites, the terrain in-between the transmitter and receiver, or the directivity of the transmit or receive antennas (i.e. antenna patterns). For example, it is possible for a very low power (1 Watt, ERP) transmitter to cause *more* interference than a higher power (1 kWatt, ERP) transmitter if the location of the receiver under evaluation is extremely close to the low power transmitter (with no terrain blockage) and far away from the high power transmitter. Therefore, in order to not waste scarce spectrum, signal strength ratios at the *receiver's antenna terminals* should be used. Of course, the *absolute* values of the desired signal are critical as well. The FCC's planning factors for "typical" receive sites (e.g. antenna gain & directionality, down-lead loss, antenna/tuner mismatch losses, receiver noise figure, SNR at TOV, etc.) should include the values of the *desired* signal levels and related D/U ratios. The planning factors for full-service station can be found in the 6th Report and Order (**Ref 14**) and its subsequent reconsideration order **(Ref 15**) as well as in OET Bulletin 69 (**Ref 3**). Further suggestions on these receive site planning factors have been given in literature (**Ref 16, 17**)

Both analog and digital television receivers were extensively lab-tested at the Advanced Television Test Center (ATTC) in Alexandria, VA during the Grand Alliance (GA) era. The Advisory Committee on Advanced Television Services (ACATS) set up committees and test plans to very carefully test the 8-VSB transmission system capability as well as the amount of interference it causes into analog and digital receivers and the amount of interference caused by analog signals into the new digital television receivers. These 1995 ATTC lab test results are reported in **Ref 7** (plus subsequent tests in **Ref 8 – 11**), and represent the only known and thoroughly investigated interference test results that have been made public (one exception is the ATTC's recent test of several DTV receivers, in **Ref 18**, but this is not an encompassing test of large numbers of units). Some of these lab measurement results are summarized in **Appendix 1** and **Appendix 2** at the end of these comments. However, it should be noted that while 24 reference analog NTSC television receivers were used, only *one* DTV receiver (the GA modem) was tested since it was the only DTV receiver available during the ACATS testing. Lab tests of DTV consumer receivers should be performed in the future.

Therefore, the D/U ratios for certain types of interference situations at various analog or digital signal desired levels are now known. It should be pointed out that the interference D/U ratios (relative signal levels) for real analog and digital receivers are *not* constant with varying *absolute* desired signal levels. However, the interference D/U ratios used by FCC as planning factors for full-service station spectrum allocation are based on measured *weak* signal level test results that do not apply directly to moderate and strong signal levels. Therefore, while the same D/U interference *methodology* should be used for translators, some of the D/U interference ratios should be altered to reflect real-world analog and digital receivers. A desirable situation is to use as much of the previous knowledge, experience, and test results from full-service DTV deployment in order to have a successful transition to digital television using translators in rural areas.

Par. 38 **Co-channel interference ratios: D-into-N**

D/U ratios for co-channel operation as found in Section 73.623(c) of the FCC rules should be used. These are the technical values determined for the terrestrial 8-VSB digital television transmission system in terms of interference to and from other signals (analog NTSC or other digital ATSC signals). These *co*-channel interference D/U ratios are as follows:

D-into-N	CCIR-3	+34 dB
N-into-D	TOV	+ 2 dB
D-into-D	TOV	+15 dB

As a point of reference, note that the DTV-into-NTSC co-channel interference ratio of 34 dB represents an interference level for a *CCIR-3* subjective impairment ("slightly annoying") and *not* an interference level that represents a TOV impairment ("just barely visible") of 51 dB (which is believed to be at least 3 – 4 dB conservative since the test was performed by pulsing the interference on and off at a 3-second rate making it easier to see and a more repeatable test). Therefore, there will definitely be noticeable interference on an NTSC television set at this +34 dB SNR value, but the "average" viewer watching the "median" receiver will find it only "slightly annoying". This indicates why CCIR-3 impairment levels should ***not*** be used when considering *co-sited* translators that essentially provide constant D/U ratios to the entire service area (and hence impose constant CCIR-3 on *all* viewers, even those close to the transmitter with strong signals). On the other hand, the D/U ratios for TOV threshold of DTV signals are essentially the same as an equivalent CCIR-3 due to the very abrupt (steep) digital "cliff effect".

The use of the co-channel *adjustment formula* for DTV-into-DTV is very accurate and reflects the addition of white Gaussian noise power and "noise-like" random-data undesired DTV power when the desired DTV signal is weak (near the noise floor of the DTV receiver). Therefore, the formula appropriately takes into account (both theoretically and practically) these two "noise" sources. The formula is repeated here in **EQN 1** for reference:

$$\mathbf{D/U = 15 + 10 * LOG\,[\,1.0/\,(1.0 - 10^{-X/10})\,]} \qquad \textbf{(EQN 1)}$$

where x = SNR – 15.19, that is, where "x" is the amount (in dB) that the actual SNR at any location exceeds the minimum SNR threshold value for TOV.

The use of the co-channel adjustment *table* for analog-into-DTV is also acceptable as it is a *conservative* approach that takes into account the lab measurements on the GA DTV prototype receiver during the ACATS testing at the ATTC laboratory. This is a conservative approach because the GA receiver employed a 12-symbol subtractive comb filter for NTSC rejection, which, when activated upon detection of a co-channel NTSC signal, degrades the receiver's white noise threshold by about 3.5 dB (noise in the main path and delayed path of the comb filter add *linearly* in *power*). Therefore, noise is enhanced when the desired DTV signal is weak and near the noise floor of the DTV receiver while the NTSC rejection comb filter is active. A table is used since calculations are not simple and the lab test measurements were carefully tabulated at ATTC.

SNR (dB)	D/U Ratio (in dB)
16.00	21.00
16.35	19.94
17.35	17.69
18.35	16.44
19.35	7.19
20.35	4.69
21.35	3.69
22.35	2.94
23.35	2.44
25.00	2.00

Table 1 NTSC-into-DTV co-channel interference adjustment table for multiple impairments (co-channel NTSC plus noise)

However, recent versions of consumer VSB chip sets have implemented improved receiver design methods to achieve the low D/U ratios for analog-into-digital co-channel interference *without* the use of the comb filter, and therefore experience little or no white noise threshold degradation under these conditions. Nevertheless, to accommodate legacy receivers, the co-channel adjustment table, as shown in the FCC rules, should be used. The data is repeated here in **Table 1** for reference:

For translator allocation calculations, the FCC proposal to use the digital-into-analog *taboo* (N±2, N±3, N±4, N±7, N±8, N±14, and N±15) D/U ratios, also found in the FCC rules in Section 73.623(c), is reasonable, but perhaps with some modifications that reflect new information that has come to light that allows better interference prediction. One should note that there is a discrepancy between the FCC rules and the OET Bulletin 69, with one of the documents apparently having a typographical error for the N+7 value (43 dB in the FCC rules appears as 34 dB in the OET Bulletin). The correct value should be declared by the FCC and used in the future. Interestingly, no lab tests were ever performed at ATTC on N+7, N-7, and N-4), so the origin of these D/U values is still unknown. **Appendix 1** contains a summary of the FCC interference D/U ratios plus pertinent ATTC measurements, where each FCC planning factor is described in terms of the amount of allowable interference (i.e. TOV or CCIR-3). The methodology to use these or similar D/U interference planning factors (after correction and update by the FCC) for *both* full-service operation and translator operation seems very appropriate since there exists a great body of knowledge and a great deal of experience with them. However, as stated above, some of the parameters might be changed to reflect new information that has come to light that better describes receiver performance. The use of constant D/U ratios for weak, moderate, and strong desired levels is also risky. Some further thought might be given to these topics.

In addition, it might be advantageous to have separate sets of values for special cases, such as *co-sited* translators. In this case, TOV interference levels should be used for DTV-into-NTSC (rather than CCIR-3). Perhaps even CCIR 4.0 or 4.5 impairment ratings (more interference, but still very good-looking pictures) can be used for interference into NTSC signals that might allow more channels to be utilized. However, these cases of slightly more interference levels into NTSC should only be for *secondary* services (translators, LPTV, on-channel boosters), *not* for primary full-service signals.

Par. 39 First adjacent channel ratios: N-into-D, D-into-N, and D-into-D

The FCC proposal of allowing **NTSC-into-DTV** interference of –48 dB for lower first adjacent channel and –49 dB for upper first adjacent channel requires some consideration, and is repeated below:

Adjacent Channel Interference	Desired Level	Impairment Threshold	D/U Ratio (dB)
Lower NTSC-into-DTV	Weak	TOV	-48
Upper NTSC-into-DTV	Weak	TOV	-49

Table 2 DTV-into-NTSC *first* adjacent channel interference planning factors proposed by FCC

These values also came from the ATTC lab tests of the GA receiver. However, the problem is that these interference ratios represent *weak* desired digital signal level conditions that do not apply at *moderate* and *strong* desired DTV signal levels. Also, there is an *assumption* that the undesired NTSC transmitter (in the real world) does not have any "splatter" energy in its adjacent channels which would act like co-channel interference and be the limiting factor rather than the usual NTSC in-band sync power overloading the DTV receiver's front end (tuner). Also, even the best production DTV tuners still are only approaching and not exceeding the –48 dB and –49 dB D/U ratios (the best coming within a few dB). Prototype tuners have been observed in the lab to make this performance specification, but currently are marginally more expensive than those used in production. ATSC's T3-S10 committee is working on some recommended receiver performance parameters that would be appropriate for FCC planning factors. A more appropriate (and conservative) interference D/U ratio value that might be considered at this time might be -43 dB for *both* the upper and lower first adjacent channel NTSC-into-DTV, which should not be very restrictive for translator coverage in rural areas far away from primary stations.

For DTV-into-NTSC and DTV-into-DTV, the FCC again refers to the FCC rules in Section 73.623(c), where the following values can be found:

Adjacent Channel Interference	Desired Level	Impairment Threshold	D/U Ratio (dB)	Comments
Lower DTV-into-NTSC	Weak	CCIR-3	-14	Tested with NO DTV splatter
Upper DTV-into-NTSC	Weak	CCIR-3	-17	Tested with NO DTV splatter
Lower DTV-into-DTV	Weak	TOV	-28	Tested with DTV splatter = stringent mask
Upper DTV-into-DTV	Weak	TOV	-26	Tested with DTV splatter = stringent mask

Table 3 NTSC-into-DTV and DTV-into-DTV *first* adjacent channel interference planning factor proposed by FCC

There are a couple of things to consider relating to the above values. First of all, the **DTV-into-NTSC** interference limits above were measured at ATTC per the ACATS test plan with ***no*** adjacent channel DTV splatter, which is not a "real world" situation. So these D/U ratios are not valid for an adjacent channel DTV signal with splatter since these limits were determined in the ATTC tests by the interfering DTV signal's *in-band* power rather than the adjacent channel splatter. In a real application, *both* the linear co-channel effects from the adjacent channel DTV splatter as well as the non-linear effects from the interfering DTV in-band power will determine the *CCIR-3* interference limit of NTSC receivers (stronger undesired signal levels causing lower D/U ratios). On the other hand, the *TOV* interference limit for an NTSC receiver is *primarily* determined by the co-channel effect from DTV splatter (weaker undesired levels causing higher D/U ratios).

Secondly, it should be noted that the above interference D/U ratios are at the *limits* of operation for both NTSC and DTV signals; that is, no acceptable margin is left in the receiver, even at strong desired levels. In other words, the CCIR-3 impairment level for analog shown above is a "slightly annoying" rating (occurring at an SNR of 34 dB), which is the worst case that the FCC allows within the Grade B contour. The TOV impairment level for DTV shown above is at the edge of the digital "cliff effect", beyond which the signal is unusable. So these values in the FCC rules are absolute limits for the *fringe* areas, and would be unsuitable for *co-sited* analog and digital *first* adjacent signals since it would put all receivers in the service area at the limit of their acceptable operation, even receivers close to the translator with strong desired signals. As a comparison to the –14 dB and –17 dB D/U ratios measured at ATTC for CCIR-3 impairment levels, **Figure 1** and **Figure 2** illustrate the results of the subsequently repeated lower and upper adjacent channel tests with DTV splatter that just meets the *original* FCC emission mask (same one described in the Sgrignoli paper as the "simple" mask). Note that the *median* values for TOV (rather than CCIR-3) are +11 dB and +7 dB for the lower and upper adjacent channel interference, respectively, which is about a 25 dB difference to the CCIR-3 results.

These interference ratios represent the limits of operation (no margin due to interference) without even considering the effects of *noise* at very weak signals that might be found *within* portions of the Grade B contour. Even though the tests were performed at weak desired NTSC signal levels, the –55 dBm test value is still about 44 dB above the noise floor of a 7-dB noise figure tuner (e.g. -106 dBm + 7 dB NF = -99 dBm). This is 10 dB *above* the 34-dB CCIR-3 impairment value for an NTSC signal). For interference into DTV, the desired weak signal level was tested at –68 dBm, which is 31 dB above the noise floor of a 7-dB noise figure tuner (i.e. 16 dB above the 15-dB TOV impairment value for a DTV signal). As with the co-channel interference case, there can be an adjustment *formula* for **DTV-into-DTV** adjacent channel interference and an adjustment *table* for **DTV-into-NTSC** adjacent channel interference. For DTV-into-NTSC interference, a more realistic and conservative set of values should be used that allows for *both* DTV splatter and receiver noise to be taken into account.

A calculation (with a formula) to take into account receiver noise while there is **DTV-into-NTSC** interference can be derived, but only if the *assumption* is made that the limiting factor of undesired DTV interference into the desired NTSC signal is due to the *linear* effects of the co-channel splatter. However, if a CCIR-3 rating is the desired interference limit (as opposed to the more conservative TOV), stronger undesired DTV interference levels will have to be accommodated (i.e. lower D/U ratios), which means that there is more likelihood of *non*-linear overload of the tuner. This is probably not a good assumption, and would therefore require a table to be created from further lab testing of the 24 reference NTSC receivers (or their equivalent) with the multiple impairments of white noise plus undesired adjacent channel DTV signals. Therefore, only the calculated values for TOV interference into NTSC receivers (linear distortion from adjacent channel DTV splatter) can be accurately determined from the methodology in the Sgrignoli paper.

However, a calculation of **DTV-into-DTV** interference can be used to account for the fact that the spectrally *non*-flat "noise-like" adjacent channel splatter will add linearly in power with any white Gaussian noise at the DTV receiver's front end when the desired signal is weak. Since the DTV receivers are modern designs and more robust to adjacent channels than an NTSC receiver, it is a better assumption that the interference limit will occur at a point that is determined by *linear* co-channel distortion from the undesired DTV splatter rather than overload from the undesired DTV in-band signal power. The fact is shown in **Appendix 2** where the upper and lower adjacent channel DTV-into-DTV results from ATTC testing are the essentially same for both weak and moderate desired signals levels. The DTV-into-DTV interference plus noise adjustment formula can be written as follows:

$$\mathbf{D/U = -[U/S\ (dB) + 10 * \log\{10^{(-THR(dB)/10)} - 10^{(-SNR(dB)/10)}\}]} \qquad \textbf{EQN 2}$$

where SNR is the white signal-to-noise ratio, U/S is the *undesired* signal's in-band-to-splatter DTV power ratio for a signal complying with a given emission mask (e.g. 39 dB for the simple mask and 44 dB for the stringent mask), THR is the desired DTV signal's TOV threshold (≈15 dB), and D/U is the required desired-to-undesired signal ratio at the location under test. A plot of the D/U interference ratio adjustment values versus receiver SNR is shown in **Figure 3**.

Co-siting translators is one method of efficiently using scarce spectrum in congested areas. For the case where *multiple* translators are co-sited, more-conservative D/U ratios are required. The Sgrignoli paper addresses this issue by describing the *general* methodology to be used when predicting interference from DTV signals (with splatter) into either NTSC or other DTV signals. The example given in this paper describes one *conservative* approach that can be used for co-siting translators, using the conservative interference level of "just barely visible" **TOV** for NTSC (rather than the "slightly annoying" CCIR-3 rating at 34 dB SNR) and **0.1 dB white-noise-threshold degradation** for DTV (rather than the TOV "digital cliff" at 15 dB SNR). This explains why these D/U interference values are "more restrictive than those given in Section 73.623(c)". The proposed values are:

Proposed Emission Mask	**Conservative D/U DTV-into-NTSC @ TOV**	**Conservative D/U DTV-into-DTV @ 0.1 dB threshold degradation**
Simple	10 dB	-7 dB
Stringent	0 dB	-12 dB

Table 4 Conservative D/U ratios for co-sited analog and digital television translators

However, as an example, one could select *less* conservative values to create the following interference limits that would allow more interference to occur to the adjacent channel signal (either an NTSC or DTV signal):

Proposed Emission Mask	***Less* Conservative DTV-into-NTSC CCIR-4.5**	***Less* Conservative DTV-into-DTV @ 0.25 dB threshold degradation**
Simple	5 dB	-12 dB
Stringent	-5 dB	-17 dB

Table 5 *Less* conservative D/U ratios for co-sited analog and digital television translators

Note that care must be taken when using DTV as the first adjacent channel *above* an NTSC channel due to the possibility of color beat and color noise (plus high frequency luminance beat) interference caused by the pilot and nearby "noise-like" DTV sidebands "leaking" through poor filtering in some NTSC sets. This is the purpose for the FCC's precision frequency offset requirement for *first upper* adjacent DTV signals. However, as will be discussed later in this reply comment, that need for precision offset can be mitigated with larger D/U ratios (lower undesired DTV signals) that are possible with co-sited, low-power television translators. Therefore, it is believed that the conservative approach in the Sgrignoli paper for D/U interference ratios coupled with the FCC-proposed 10-dB power back-off (analog peak sync to average DTV power) will provide a safe implementation for facilities with many *co-sited* analog and digital translators (similar to MMDS microwave implementations).

Par. 40 Multiple emission masks and related D/U ratios

The proposed multiple emission masks (simple and stringent) by Sgrignoli, if allowed by the FCC, would allow a *choice* to be made by the translator operator when filing for a translator license. It is believed that many existing analog translators will be converted to digital for initial operation. A simple mask may be the most popular choice since it is easiest to meet, especially if there are no adjacent channels. However, if there are adjacent channels, the D/U ratio for acceptable interference will change. But it should be noted that even the *simple* mask allows 10 dB power ratios between *co-sited* NTSC and DTV translator signals, which is the proposed FCC power ratio for analog and digital signals. It is clear that if an analog signal is situated "between" *two* digital signals, 3 dB more protection is needed, which can be achieved by either by using the stringent emission mask or by backing off the power of each DTV signal by 3 dB (producing a *total* splatter back-off of 3 dB as well, assuming that splatter energy tracks with the in-band power). If a translator has an adjacent channel neighbor start broadcasting at a later date, the appropriate ERP levels must be chosen to avoid interference or the emission mask must be changed (preferably, a minor change application with the FCC). Also, while the co-sited multiple-channel translator's situation is fairly straightforward and optimal for spectral efficiency, the stringent mask may be needed for those situations where protection for a distant adjacent channel station is required (e.g. a full-service analog or digital station).

It should be pointed out that the Sgrignoli emission masks (simple and stringent) focus on the adjacent channel DTV splatter's effect on a *first* adjacent analog or digital signal. Beyond the first adjacent channel, the level of splatter or harmonic energy can be independently regulated by additional means. For instance, at the Global Positioning Satellite (GPS) frequencies beyond 1 GHz, or land mobile frequencies contained within channels 14 –20 in the largest 13 cities, or radio astronomy frequencies within UHF channel 27, the rules can specifically state that there must be a required amount of attenuation or a maximum allowable absolute power at the translator's antenna output to protect those services in those bands without requiring severe requirements on the energy within the television band. This is similar to what the digital audio broadcast (DAB) rules dictate. This methodology is preferred over requiring everything at the band-edge (and beyond) of the adjacent television channel to be extremely attenuated. This allows for simpler harmonic filters to be implemented for those DTV channels whose *harmonics* fall within the GPS or radio astronomy bands. While a very steep filter might be needed for a translator if placed next to a land mobile band in the channel 14–20 region, translator operators would probably avoid these channels. Also, since these land mobile channels exist only in the vicinity of the largest 13 cities, and most translators are out in rural areas, it is unlikely that low-power rural translators would have any interference affect on these land mobile signals.

Par. 41-49 **Interference prediction methodology**

Interference prediction methodology for the application process should be consistent between full-service television stations and low power television translators. The most accurate prediction methodology uses the Longley-Rice terrain-dependent propagation model as described in OET Bulletin 69 (**Ref 3**). While it is easier to deal with the "grade contour" approach, there are too many shortcomings, especially when spectrum is so scarce in many areas, and the transition to digital is imminent. There is Longley-Rice software readily available to translator operators and their consultants. Every factor should be taken into account, such as transmitter antenna HAAT and directional and elevation patterns, terrain variations, interference effects, receive antenna gain and directionality. More appropriate elevation gain patterns for commonly used antennas should definitely be used to increase the accuracy of the prediction method for translator operations. And addition of D/U ratios to the planning factors specifically for co-sited translator operations is important as well. Translator operators need to utilize spectrum as efficiently as possible, especially during the transition period. Therefore, the most efficient and accurate methodology and technology must be used in order to find as many channels as possible without causing an unacceptable increase in interference to full-service stations or other existing translator operations.

Par. 51-56 **Co-located operation on adjacent and taboo channels**

Co-location (or co-siting) of adjacent channel and taboo analog and digital translators is indeed one of the most promising methods for efficiently using previously prohibited spectrum. Longley-Rice modeling should be employed, and every effort should be made to use good engineering design to carefully allocate as many DTV channels as possible without causing undue interference. Often, the "lack" of spectrum in some rural areas exists because of application of the analog taboo interference rules. With certain restrictions and careful system design, many of the previously unused RF channels can be utilized by co-sited DTV signals.

The Sgrignoli paper calculates DTV-into-NTSC D/U interference ratios for TOV (***not*** CCIR-3) as 10 dB for the simple mask, and 0 dB for the stringent mask. So, under a *co-sited* condition, if the average power of a DTV signal is the FCC-recommended 10 dB below the adjacent NTSC peak sync power, no interference should be experienced to a median analog receiver tuned to the NTSC channel regardless of which emission mask is used. **Figure 1** and **Figure 2** show the ATTC test results for the upper and lower adjacent channel tests using an undesired DTV signal with splatter equal to the proposed simple mask (note that this is the same as the *original* FCC mask). Note that the upper adjacent channel median D/U ratio is +7 dB while the lower adjacent channel median D/U ratio is +11 dB. The lower adjacent channel case just misses the 10-dB power "backoff" between DTV and NTSC, but remember that the test methodology is at least 3-4 dB conservative due to the pulsing of the interference on and off at a 3-second rate. Therefore, if this curve were shifted lower by just 3 dB, even the worst case NTSC receiver would have a TOV interference threshold of 10 dB (i.e. not just the median set is below TOV, but 100% of the *reference* NTSC sets is at or below TOV). Also, in the pursuit of accommodating as many translator stations in the spectrum as possible during the transition, it might be prudent to allow either CCIR-4.5 or even CCIR-4.0 levels of interference into other *translator* analog signals since these levels of interference still produce very good pictures (perhaps better than is possible right now even without the digital signals present).

The stringent emission mask can then be reserved for special cases where more margin is needed for a more conservative approach (e.g. if an NTSC signal is "sandwiched" in-between two DTV signals, and each of the adjacent channel DTV splatters add up to interfere with the NTSC signal). Of course, the stringent emission mask may be needed if there is a *primary* station's NTSC signal (from a distant city) in the area that needs additional protection.

The chart in **Figure 4** illustrates *all* of the interference **DTV-into-NTSC** adjacent channel/taboo channel D/U ratios for the *median* analog TV set at ATTC (**Ref 7, 8, 9, 10, 11**). Note that these are TOV values, which is already a conservative approach (estimated 3-4 dB) since the ATTC tests were performed with the interfering DTV signal pulsed on and off at a 3-second rate. Also note that the D/U ratios vary with the desired NTSC level. From these test results, it is seen that the *median* TV set (i.e., half of the 24 reference TV sets) at ATTC could easily handle a 10 dB NTSC-to-DTV ratio. Of course, each situation can be evaluated with Longley-Rice methodology to see what exact transmitted power ratios can be handled for a given translator *system* design. Also, the use of TOV is a conservative approach in general since it was tested by pulsing the interference signal, and produced a 51 dB D/U requirement. As mentioned above, perhaps in some instances, a CCIR-4 rating (perceptible impairment, but not annoying) could be used. This has an equivalent SNR of about 43-44 dB, which is a very clean picture to watch in any area (urban or rural). The additional amount of interference at CCIR-4 over TOV might be 7- 8 dB, which would then allow more DTV channels during the transition, speed up the transition, and bring the analog turn-off sooner rather than later. The FCC planning factors in use for full-service stations and proposed in this NPRM clearly show that taboo channel operation from *co-sited* translators where multiple DTV signals are all equal power (approximately) and 10 dB below (multiple) NTSC sync powers should produce no interference to either analog or digital television receivers.

The Sgrignoli paper calculates co-sited DTV-into-DTV D/U interference ratios for 0.1 dB threshold degradation (***not*** TOV, which occurs at the "digital cliff") as –12 dB for the simple mask and –17 dB for the stringent mask. Therefore, co-sited DTV signals that are typically equal power (certainly within 3 dB of each other) should not cause interference to DTV receivers that are tuned to other DTV channels, regardless of which emission mask is used. Likewise, the stringent emission mask might be used for situations where more operational margin might be needed. Of course, it is also beneficial to use the stringent emission mask if there is a distant adjacent channel full-service DTV signal that may need additional protection.

While the FCC must determine the official (or legal) definition of "co-located" (or "*near*-co-located"), it is technically better for obtaining minimal differential signal propagation effects if a more stringent location requirement is used than for full service stations (3 miles/5 km). Of course, co-siting is the best (i.e. same antenna farm or even the same tower), and should at least be greatly encouraged by the FCC.

Par. 56 Precision frequency offset for DTV

Precision frequency offset is required in full-service DTV stations that are the *first* adjacent channel *above* an analog NTSC signal. It can be an expensive process to implement if the transmitters are *not* co-sited and the analog NTSC exciter is an older model with no reference frequency-input capability. Also, not only the visual carrier and pilot carriers must be precisely frequency-locked together, but also the NTSC color subcarrier.

The color beat that led to this requirement was noticed at the ATTC lab tests during the GA testing (**Ref 7**). Further tests were subsequently performed at ATTC (**Ref 8, 9**) to study the effects and the offset performance. It is caused by the lower end of the adjacent DTV channel leaking through analog receiver IF band-pass filter, sound trap, and chroma takeoff circuits in *some* analog TV receivers (but not all). The DTV pilot as well as the "noise-like" data sideband energy near the pilot get through these NTSC filters, with the pilot creating a low-frequency (1.48 MHz) color beat signal in the form of diagonal stripes.

However, the color beat was most noticeable at *large* interfering levels (D/U < 0 dB) that were evaluated at ATTC at the time since there was no DTV splatter present during the tests per the ACATS test plan. The largest D/U ratio at which it was observed (i.e. smallest interference level on the *worst* analog sets) was +4 dB (**Ref 7**). Also, the color beat is somewhat "hidden" by the color and luminance noise that accompanies the color beat as well as any other naturally occurring signal impairments (e.g. white noise, multipath, etc.) or interference (co-channel analog, etc.).

If the D/U ratios in the service area are kept fairly large (DTV signal much lower than NTSC by at least 10 dB), the color beat in those poorly designed analog sets should *not* be a problem, even without any DTV pilot carrier frequency offset. Therefore, this is feasible in *co-sited* translator situations. However, if by chance there is a statistically significant problem found in the analog sets in the service area, a <u>non</u>-precise pilot frequency offset can be used (+22.727 ± 1 kHz) to remove (or at least significantly reduce) the color beat. But this should be a last resort, as it will add cost and complexity for many translator operators. The remaining high frequency luminance beat (5.082 MHz) is not a significant problem in this instance, and can be ignored in translator operations.

Par. 57 Any other technical means for interference avoidance

Interference avoidance can be accomplished by careful selection of signal power, channel frequency, and transmitter location. At this point, it appears that using low DTV transmitter power, carefully limiting DTV splatter, and controlling D/U ratios throughout the service area are the best methods at hand for interference avoidance. Co-siting analog and digital translators can accomplish all these things. The list below contains some approaches that can be used during the planning of transmitter *co-siting* to minimize the differential propagation effects and provide consistent D/U ratios throughout the service area. Many of these are obvious, and have been put to use for years by translator operators.

1) Select *best site* for co-sited translators (*highest* HAAT allows more line-of-sight reception and lower power)
2) *Common tower* for all the desired signals (*controlled* ratios of adjacent and taboo channel signal strengths)
3) Use *common* broadband antennas (same azimuthal and elevation patterns, same HAAT, same beam tilt)
4) If not same antenna, then *identical antenna models* on same tower at approximately the same height & beam tilt
5) If possible, use *alternating* RF channels (avoiding first adjacent channels)
6) Use the *least* amount of DTV power to safely (conservatively) cover the service area
7) If possible, operate all *analog* channels at *same* (or nearly the same) peak sync power (ERP)
8) If possible, operate all *digital* channels at the *same* (or nearly the same) average power (ERP) and 10 dB below the peak sync power of the NTSC signals
9) Use *same test equipment* to measure in-band powers of all NTSC and DTV signals (less relative variation)

10) Use *common combiners* and *feed-line* for matching output powers
11) Use *directional antenna* patterns that may allow re-use of the same frequency in not too-distant communities.
12) If DTV and NTSC are required to be *first* adjacent channels, put DTV at the first channel *below* NTSC
13) Only if necessary, place DTV immediately *above* the NTSC signal, with *no frequency offset* (if NTSC/DTV power ratio is 10 dB or more)
14) As a *last* resort, if there is statistically *significant* proof that a color beat is showing up in more than half the color TV sets in the service area, apply a ***non***-precise frequency offset (+ 27.727 kHz ± 1 kHz)

Par. 61 Analog and DTV power limits

The maximum power levels for translators that were previously set by the FCC are:

Channels	Analog Peak ERP	Digital Average ERP
2 - 13	3 kW	300 Watts
14 - 69	150 kW	15 kWatts

Table 6 Maximum translator power levels

The FCC-proposed digital ERP limits for translators (and LPTV) were set to values 10 dB *below* the corresponding analog ERP limits. This is very reasonable, as power ranges between 7 and 12 dB below have been commonly referred to previously. The 7-dB ratio is the one used in full service stations (e.g. max ERP at UHF for analog and digital channels is 5 MWatts and 1 MWatts, respectively, which is a 5:1 ratio, or 7 dB). This value also allows all the significant DTV peaks (0.01% of the time as measured at ATTC) to be below the equivalent analog peak sync power (good for transmitter "clipping limits"). The 12-dB ratio is the one first estimated by the ACATS group for equivalent coverage to replicate a CCIR-3 rating for an analog picture (with some assumptions of channel frequency and HAAT). Therefore, the proposed 10-dB value is a good compromise that provides some margin for both DTV service and interference. Since most translators are placed on a large hill or mountain and provide line-of-sight to most of their viewers, smaller radiated power is more than adequate.

These maximum powers appear to be fairly large for most *translator* operations, and therefore probably reflect the requirements of LPTV stations that often reside in urban areas rather than translators that reside in rural areas. Obviously, lower transmitted power produces less interference, which then allows more DTV stations to be utilized.

Par. 62 – 70 NTSC and DTV emission mask definition

The full service DTV broadcast emission mask, described in the FCC rules and analyzed in the Sgrignoli paper, is a very strict mask, primarily in the outer 3 MHz of each adjacent channel. It cannot be measured directly with a single piece of equipment in a single sweep, but rather must be measured in a *two*-step process. As described in the Sgrignoli paper, this *full-service* DTV mask does *not* contribute to the protection of the *first* adjacent channel analog or digital signal beyond its attenuation level at 3 MHz (mid-way) into the adjacent channel. That is why the *stringent* emission mask (a *modified* form of the full-service mask) is proposed, providing the same adjacent channel protection as the current full-service mask, but in a manner that is much easier to achieve and measure in practice. On the other hand, the *simple* mask provides less protection to adjacent channels, but can be easily achieved by most translator equipment, including the commonly used 3-section resonator filter found in most analog translators in the past 10 years. The stringent mask requires the same type of band-pass filter, but typically 5 sections instead of 3 sections. According to manufacturers, the additional cost is *not* significant.

To avoid potential confusion, the following is a brief explanation of the emission mask compliance. Rigid emission mask compliance is dependent on *two* parameters: (1) the naturally occurring splatter energy caused by transmitter non-linearities such as 3rd and 5th order intermodulation, and (2) the stop-band attenuation of the emission mask band-pass filter employed at the transmitter output. The filter by itself does *not* determine the emission mask compliance. The Sgrignoli paper used the 3-section and 5-section coupled-resonator filters along with a LARCAN MX-100 transmitter as an *example* of how transmitter splatter might comply with the two proposed emission masks. Certainly, other transmitter and filter combinations are possible. Lower power transmitters might have better linearity, have less splatter at their rated output, and require less filtering (less attenuation needed in stop-band). Therefore, emission mask compliance depends on the *combination* of the transmitter's splatter and the band-pass filter's stop-band attenuation. It has been determined that for a 300 Watt average TPO, compliance with either the simple or stringent emission mask is both possible and affordable.

As noted previously, *any* emission mask that is different from the one used for the full service DTV stations should take care to still require proper attenuation at special frequencies, such as the GPS band and radio navigation satellite service (RNSS) operations at 1559-1610 MHz (L1), 1215-1240 MHz, and 1164-1188 MHz, as well as land mobile (channels 14 – 20 in the 13 largest cities) and radio astronomy (channel 37). If necessary, any special frequency bands of interest can still have stringent attenuation requirements to protect against 2nd and 3rd harmonics from translators. That is, special frequency bands can be determined where the emission mask is required to have significant amounts of attenuation. Except for the CH 14 – CH 20 land mobile band, these bands will *not* be within the VHF and UHF television band, thereby allowing simple low cost harmonic filters to be used (if needed at all, in addition to the mask filters).

As far as selection of one of the emission masks is concerned, it is *independent* of the translator ERP. It is purely a tradeoff of *cost* versus *D/U interference ratios*. For example, a larger power translator may *choose* to use the simple mask if there are no adjacent channels in the service area. However, a very small translator ERP might *require* a stringent mask if the extra adjacent channel interference protection is needed for nearby areas that are trying to receive a weak signal from a far-away full-service station. So it is a matter of making optimal tradeoffs. It is expected that most of the translator operators would naturally try to use the simple mask, which requires the simplest, lowest cost filter. The stringent mask might only be used if it were necessary to add another channel or if more margin was needed to guarantee that no new interference existed. Use of either mask in interference prediction can be accommodated as long as the different D/U ratios are known for each mask. The Sgrignoli paper clearly shows the general *methodology* to calculate different D/U ratios for *different* situations should the need arise (e.g. 0.25 dB DTV threshold degradation, or CCIR-4 NTSC interference threshold).

There has been much discussion in the translator industry regarding the transition to digital television, and how to hasten it. There are some translator operators who will desire to initially convert older analog translator units to digital. Upon doing so, they may not be able to meet even the simple emission mask due to "spectral shoulders" (or "shelves") that are less than 35 dB down from the flat top part of the DTV spectrum. Of course, other older units may be compliant after some bias adjustments. And new units using modern technology such as LD-MOS Field Effect Transistors (FET) should have no problem meeting the 35 or 36 dB "close-in" shelves.

Some in the broadcast business have suggested "*grand-fathering*" these incumbent translators to allow an *even simpler* mask (same spectral shape, but with close-in shelves that are < 35 dB). Others have proposed doing this with a *waiver* on a case-by-case basis. These are matters for FCC consideration. However, I would suggest using the same amount of *absolute protection* from DTV sideband splatter in *all* cases in order to help guarantee a successful deployment of rural translators.

In order to combat this increased adjacent channel splatter (shelves *less* than 35 dB due to the use of some older translator units) and to keep all the splatter *interference* the same, I agree with the principle that the in-band average power be reduced one dB for every dB that the close-in shelves are less than 35 dB down from the flat-top part of the in-band spectrum. This way, the *total* adjacent channel splatter energy would have the *same* interference power (assuming the same splatter spectral shape exists), but the in-band power is *de-rated*. For example, if the translator output shelf can only be adjusted to -32 dB (in the case of asymmetrical shelf attenuation, use whichever side has the least/worst-case attenuation), which misses the simple mask by 3 dB, then the in-band power should be lowered (de-rated) by 3 dB. Longley-Rice methodology can then determine how much service loss there is, if any. In many cases, this power reduction should still easily provide the desired service area.

The advantage of de-rating the in-band power is to not only limit the amount of interference, but also to encourage (and motivate) the translator operator to move towards improved performance in the future without increasing interference. Upon subsequently meeting the simple (or stringent) emission mask in the future, the translator operator can increase the output ERP to the original allocated level.

Finally, the selection of a measurement bandwidth of 500 kHz is reasonable, as long as it is understood that other measurement bandwidths can be used (e.g. 30 kHz) and then corrected for bandwidth by the familiar equation:

$$\mathbf{C.F.} = \mathbf{10 * \log (BW2 / BW1)} \qquad \textbf{EQN 3}$$

Also, this keeps the definition consistent with that used in the full service DTV rules (Section 73.622 (h)), and avoids confusion within the full-service and low power television industries.

CONCLUSION

The two proposed emission masks are both workable and affordable, giving the translator operators some flexibility. Moderate to low radiated powers should be all that DTV translators need to transmit to cover large open areas, thus avoiding some of the interference in the spectrally-crowded (urban) regions of this country. The D/U ratios that are employed in spectrum allocation and interference prediction are crucial to quickly and successfully transitioning to digital television. Different D/U ratios can be utilized depending on the emission mask used. Also, interference thresholds (TOV versus CCIR-3 versus some partial margin reduction such as 0.1 dB threshold degradation) should be carefully selected, and different D/U ratios should be used depending upon whether the desired signal is at weak, moderate, or strong levels. Likewise, different D/U ratios for planning factors of co-sited translators can be employed.

Quick action is needed by the FCC to begin the DTV transition in the rural areas and bring it to a timely completion. The DTV transition in rural areas of this country, where spectrum crowding is *not* as severe as major urban centers, should not be impeded. Carefully engineered *co-sited* translators can provide many channels of DTV and (clean NTSC during the transition) to viewers who have become accustomed to having little and/or poor-quality local television. More DTV education (conferences, published papers, seminars, etc.) in the broadcast industry will help to facilitate the successful transition from analog to digital in all areas of the country.

Respectfully submitted by:

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APPENDIX 1

Current FCC Interference Planning Factors			
Planning Factor	**FCC Rules 73.623(c)**	**OET-69** *{Table 5a & 5b}*	**ACATS / ATTC { I-3-14 to I-3-26}**
	D/U Ratio (dB)	*D/U Ratio (dB)*	*D/U Ratio (dB)*
Co-Channel:			
DTV-into-NTSC (CCIR-3)	+34	+34	+33.81
NTSC-into-DTV (TOV)	+ 2	+ 2	+ 1.81
DTV-into-DTV (TOV)	+15	+15	+15.27
Lower Adjacent Channel:			
DTV-into-NTSC (CCIR-3) see **Note 2**	**-14**	**-17**	-15.96
DTV-into-NTSC (TOV) see **Note 4**	---	**---**	+11.33
NTSC-into-DTV (TOV)	-48	-48	-47.61
DTV-into-DTV (TOV) see **Note 3**	**-28**	**-42**	-41.98
Upper Adjacent Channel:			
DTV-into-NTSC (CCIR-3) see **Note 2**	**-17**	**-12**	-16.91
DTV-into-NTSC (TOV) see **Note 4**	---	**---**	+7.33
NTSC-into-DTV (TOV)	-49	-49	-48.54
DTV-into-DTV (TOV) see **Note 3**	**-26**	**-43**	-43.17
UHF Taboo Channels: DTV-into-NTSC			
N-2 (TOV @ weak)	-24	-24	-23.73
N+2 (TOV @ weak)	-28	-28	-27.93
N-3 (TOV @ weak)	-30	-30	-29.73
N+3 (TOV @ weak)	-34	-34	-34.13
N-4 (TOV @ weak) see **Note 6**	-34	-34	------
N+4 (TOV @ weak)	-25	-25	-24.96
N-7 (TOV @ weak) see **Note 6**	-35	-35	------
N+7 (TOV @ weak) see **Note 5, 6**	**-43**	**-34**	**------**
N-8 (TOV @ weak)	-32	-32	-31.62
N+8 (TOV @ weak)	-43	-43	-43.22
N+14 (CCIR-3 @ weak)	-33	-33	-33.38
N+15 (CCIR-3 @ weak)	-31	-31	-30.58
UHF Taboo Channels: NTSC-into-DTV			
N-2 (TOV @ weak)	NC	NC	-62.45
N+2 (TOV @ weak)	NC	NC	-59.86
N-3 (TOV @ weak)	NC	NC	< -61.79
N+3 (TOV @ weak)	NC	NC	< -62.49
N-4 (TOV @ weak)	NC	NC	-----
N+4 (TOV @ weak)	NC	NC	-----
N-7 (TOV @ weak)	NC	NC	-----
N+7 (TOV @ weak)	NC	NC	-----
N-8 (TOV @ weak)	NC	NC	-----
N+8 (TOV @ weak)	NC	NC	-----
N+14 (CCIR-3 @ weak)	NC	NC	-----
N+15 (CCIR-3 @ weak)	NC	NC	-----
UHF Taboo Channels: DTV-into-DTV			
N-2 (TOV @ weak)	NC	NC	< -60.52
N+2 (TOV @ weak)	NC	NC	< -59.13
N-3 (TOV @ weak)	NC	NC	< -60.61
N+3 (TOV @ weak)	NC	NC	< -61.53
N-4 (TOV @ weak)	NC	NC	-----
N+4 (TOV @ weak)	NC	NC	-----
N-7 (TOV @ weak)	NC	NC	-----
N+7 (TOV @ weak)	NC	NC	-----
N-8 (TOV @ weak)	NC	NC	-----
N+8 (TOV @ weak)	NC	NC	-----
N+14 (CCIR-3 @ weak)	NC	NC	-----
N+15 (CCIR-3 @ weak)	NC	NC	-----

Note 1: **BOLD** values in the FCC rules and OET 69 columns are inconsistent with each other, and subject to correction by the FCC. "NC" denotes "Not Considered". A TOV *subjective* impairment is defined for both analog and digital signals as threshold of visibility, and is the level of interference that is just barely visible (for DTV, this corresponds to a MEG *packet*-error rate of 2.5 packets/second). A CCIR-3 subjective impairment rating describes a level of interference that is statistically described by the "average" viewer as "slightly annoying". CCIR-3 interference is much more noticeable to the typical viewer than TOV.

Note 2: ATTC tests of *both* upper and lower adjacent DTV-into-NTSC were performed without DTV splatter according to the original ACATS test plan.

At all three of the *desired* NTSC signal levels (strong/-25 dBm, moderate/-35 dBm, and weak/-55 dBm) during ATTC *upper* adjacent channel testing, a "diagonal stripes" ("color beat") problem occurred during the camera-pan in the "Texas Sign Dude" sequence. During the camera-pan, equivalent CCIR-3 interference levels (due to the beats) were observed at a lower level of interference than the final impairment level voted on by the expert observers (for the entire sequence). Subsequently, it was confirmed by experiment that the beat pattern was actually constant, but that it became noticeable during motion of the image due to eye-tracking of the motion by the expert observers. This interfering beat was due to the small DTV pilot carrier "leaking into" the chroma demodulation circuitry of *some* of the analog TV sets and creating a *low*-frequency visible color beat (1.48 MHz, which is the difference between the desired NTSC chroma subcarrier and the undesired adjacent channel DTV pilot carrier). For those affected analog sets that exhibited this color beat interference, it was the dominant *video* impairment. In addition to the beat, color *noise* and color *de-saturation* effects were observed. Also, at these CCIR-3 D/U ratios and discounting the color beat interference, it was found that *audio* impairments were the predominant limiting factor.

However, when adjacent channel DTV splatter is taken into account and the precision DTV frequency offset is used to remove the low-frequency color beat and high-frequency luminance beat, video (rather than audio) is then the predominant limiting factor. With DTV splatter just meeting the current FCC emission mask, DTV-into-NTSC TOV interference was measured as +7 dB and +11 dB for upper and lower adjacent channel interference, respectively.

For **strong** desired NTSC signal levels (-25 dBm), this *CCIR-3* color beat interference occurred in 10 of the 24 reference sets (e.g. D/U = +3 dB for 9 analog TV sets and D/U = +4 dB for 1 analog TV set). For **weak** desired NTSC signal levels (-55 dBm), 8 of the 24 sets exhibited this color beat interference (e.g. D/U = - 2.9 dB *worst* case).

At **weak** NTSC levels, only 4 of the 24 reference analog TV sets exhibited worse than the *TOV* interference from a DTV signal at D/U ≈ +10 dB. (Remember that TOV is a very sensitive test, and is determined by pulsing the interference signal on & off).

The **DTV** carrier frequency offset *mandated* by the FCC for upper DTV-into-NTSC situations is an odd multiple of half NTSC horizontal line rate ($90.5*F_H$), and causes the (1.48 MHz) pilot beat to alternate from NTSC video line to the next, thus being integrated in the observer's eye, which reduces this beat to insignificance. The additional 29.97 Hz precision offset required by the FCC is to reduce the 5.08 MHz *luminance* beat (between NTSC visual and DTV pilot carriers), which is less objectionable than the color beat. However, the color *noise* and *de-saturation* problems remain.

Note 3: These initial ATTC tests were performed according to the ACATS test plan with *flat* adjacent channel DTV splatter more than 51 dB (perhaps as much as 57 dB) below the nearly flat in-band spectrum. Therefore, the DTV-into-DTV adjacent channel interference tests did not take into account real-world DTV adjacent channel splatter from typical high-power amplifiers (HPA), which will be the limiting factor in practice. The new values of planning factors were obtained from subsequent ATTC testing that used DTV adjacent channel splatter equal to the *original* FCC emission mask (-23 dB for lower adjacent channel and -21 dB for upper adjacent channel), and then corrected *mathematically* for the 5 dB integrated splatter improvement that the current FCC mask has (-44 dB) over the original mask (-39 dB).

Note 4: The ATTC results are for testing done with adjacent channel splatter equal to the *original* FCC rigid emission mask.

Note 5: A **typographical** error in the FCC rules (perhaps transposing the 3 and the 4 to get 43 dB instead of 34 dB).

Note 6: ACATS did not authorize tests involving DTV-into-NTSC for N-4, N-7, and N+7 taboo interference, so there is no laboratory test data known on which to base these D/U ratios.

APPENDIX 2

ATTC Laboratory Interference Performance Tests @ TOV

With DTV Splatter Equal to *Original* FCC Emission Mask

Channel Offset from desired	DTV-into-NTSC Median TOV D/U Ratios			NTSC-into-DTV Median TOV D/U Ratios			DTV-into-DTV Median TOV D/U Ratios		
(±)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)
	Strong	Moderate	Weak	Strong	Moderate	Weak	Strong	Moderate	Weak
-8	- 6.90	-16.11	-31.62	-----	-----	-----	-----	-----	-----
-3	- 1.73	-18.28	-29.73	< -22.07	< - 47.06	< - 61.79	< - 20.95	< - 45.98	< -60.61
-2	- 1.43	-15.00	-23.74	< -23.09	< - 48.23	- 62.45	< - 21.83	< - 46.80	- 60.52
-1	**-----**	**+ 11.33**	**-----**	< - 23.18	- 44.46	- 47.73	-----	- 23.09	- 22.83
0	-----	+ 51.27	+47.74	-----	+ 1.40	+ 1.81	-----	+ 14.78	+ 15.27
+1	**-----**	**+ 7.33**	**-----**	< - 23.18	- 44.44	- 48.71	-----	- 21.15	- 21.15
+2	- 3.80	- 17.47	-27.94	< -23.88	< - 48.87	-59.86	< - 22.35	< - 47.33	- 59.13
+3	- 5.55	- 19.79	-34.13	< -23.10	< - 48.08	< - 62.49	< - 21.99	< - 46.98	< - 61.53
+4	- 5.60	- 18.22	-24.96	-----	-----	-----	-----	-----	-----
+8	- 9.77	- 22.97	-43.22	-----	-----	-----	-----	-----	-----
+14	- 8.40	- 22.24	-29.55	-----	-----	-----	-----	-----	-----
+15	+1.29	- 14.54	-17.58	-----	-----	-----	-----	-----	-----

General Comments:

An entry with dashed lines (-----) indicates that no ATTC laboratory tests were performed according to the ACATS test plan.

An entry with a "<" indicates that the ATTC test bed could not produce an undesired signal large enough to reach the threshold for the median NTSC receiver or the Grand Alliance DTV prototype receiver.

TOV (threshold of visibility) is the most sensitive impairment level. For both analog and digital reception, it is the point where interference is just visible to expert observers looking at repeating video clips. For DTV reception, this corresponds to an MPEG packet-error rate of 2.5 packets/second.

All DTV-into-NTSC tests for TOV were performed by *pulsing* the undesired DTV signal on and off at a 3-second rate, which provides repeatability and possibly a few dB of implementation margin to the *average* viewer experiencing a *constant* interference.

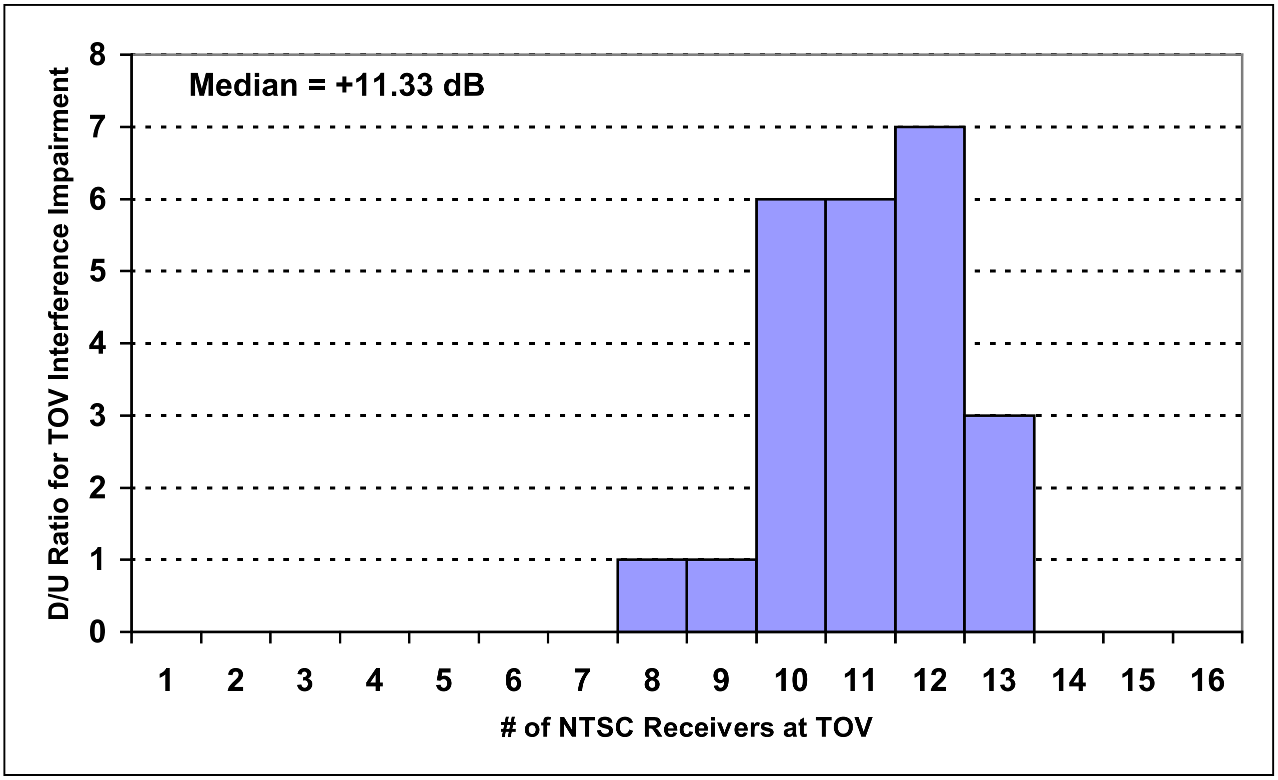

Figure 1 *Lower* Adjacent Channel DTV-into-NTSC with DTV splatter present (equivalent to *original* FCC mask)

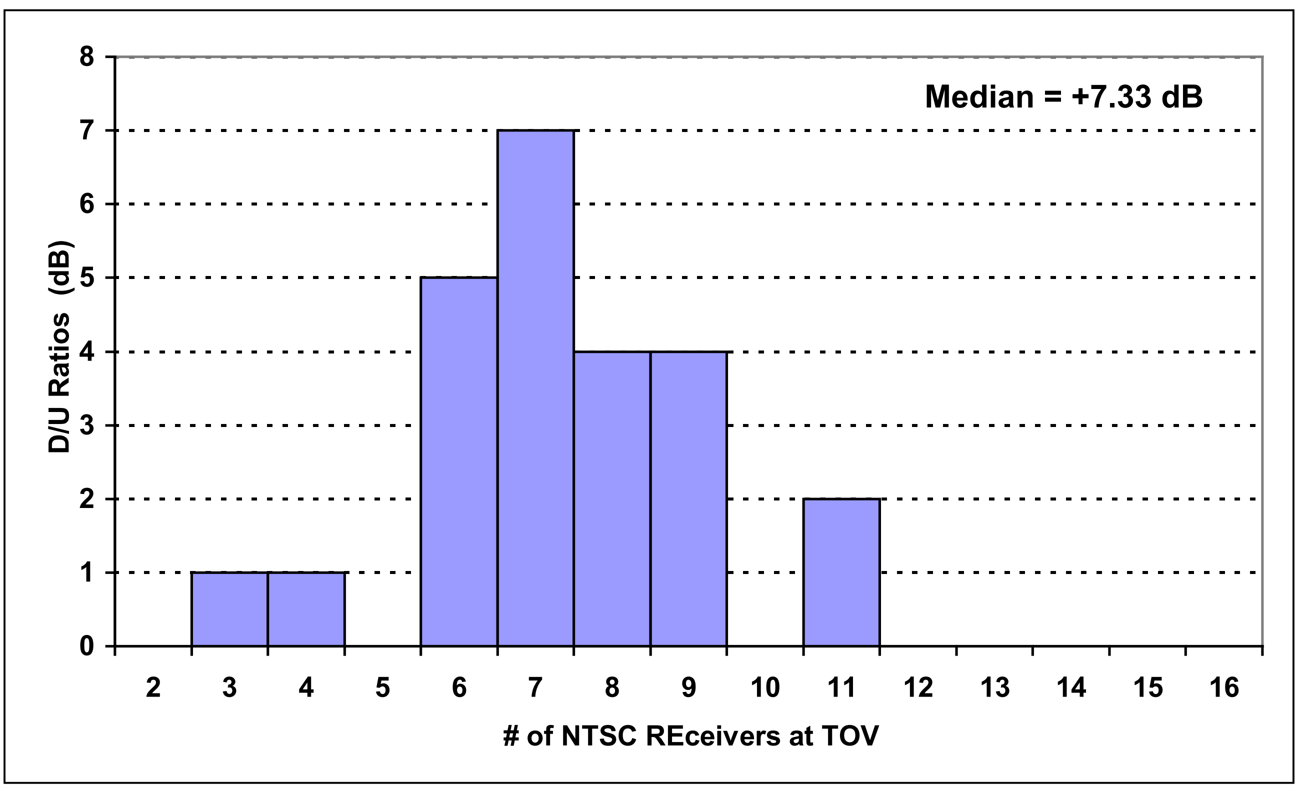

Figure 2 *Upper* Adjacent Channel DTV-into-NTSC with DTV splatter present (equivalent to *original* FCC mask)

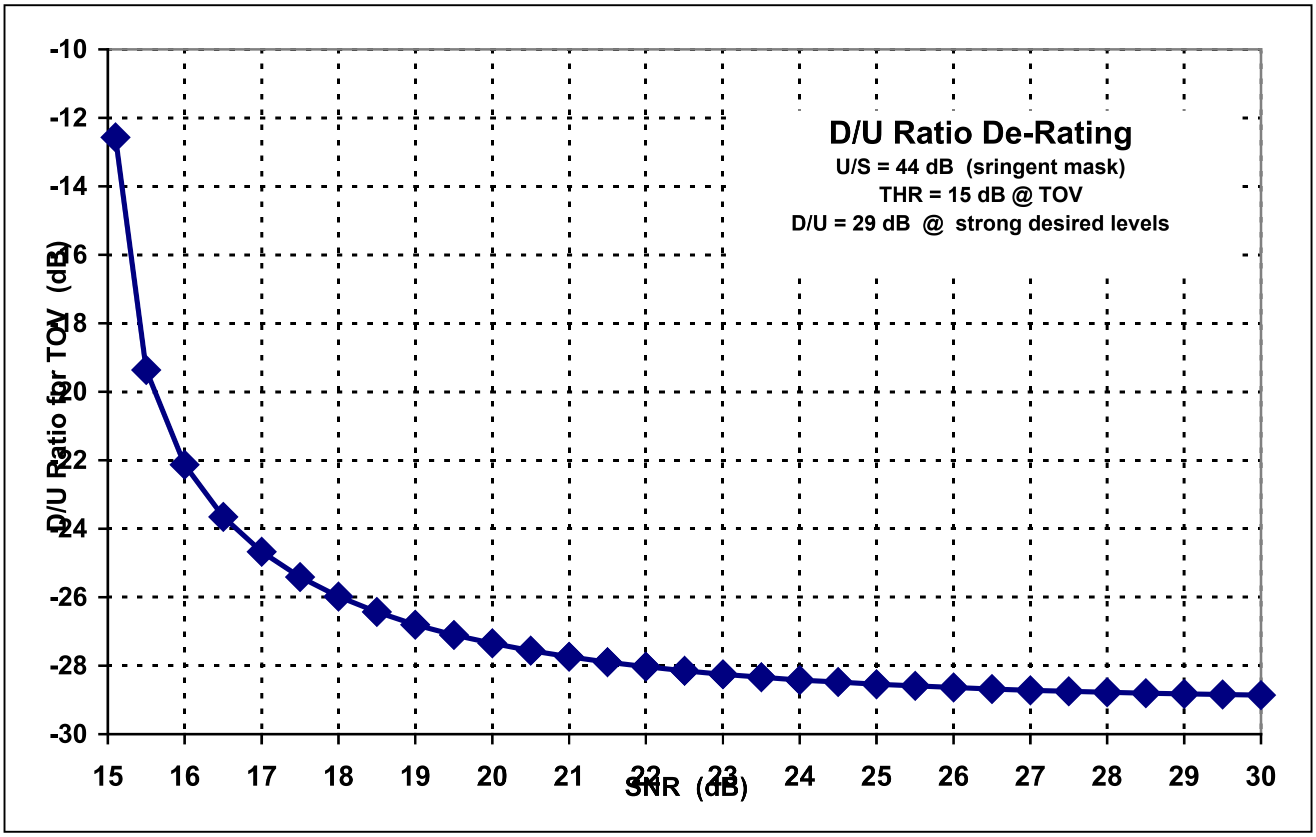

Figure 3 DTV-into-DTV adjacent channel (upper or lower) interference plus white noise *adjustment* chart

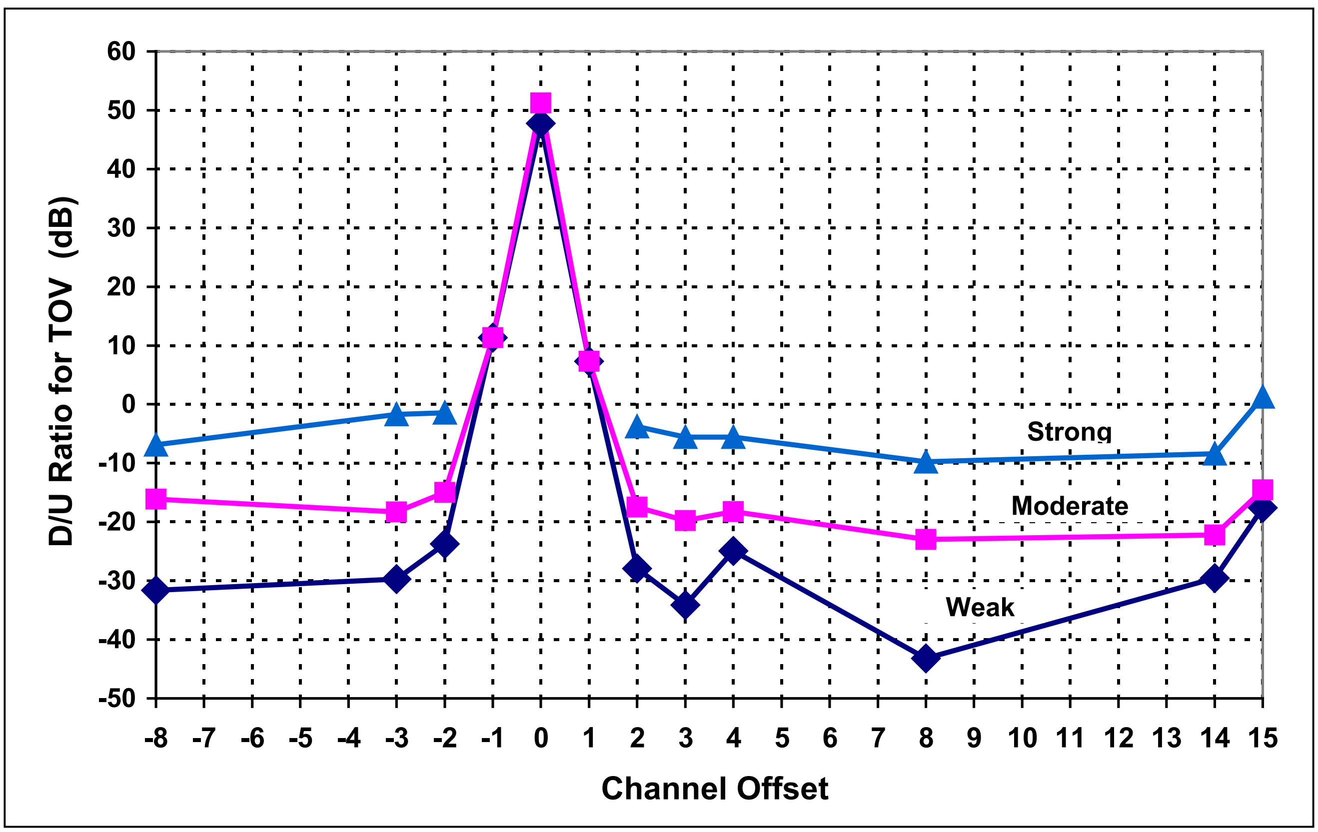

Figure 4 ATTC measurements of D/U ratios for ***TOV*** impairment levels at weak, moderate, and strong *desired* levels